CHAPTER 3

AFFECTED ENVIRONMENT, IMPACTS, ALTERNATIVES, MITIGATION MEASURES AND SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS

This chapter describes the affected environment, impacts of the *Proposed Action* and alternatives, mitigation measures, and any significant unavoidable adverse impacts on the environment anticipated from implementation of the *Proposed Action* or alternatives. Mitigation measures are included for consideration as part of the decision-making process for the proposal.

3.1. EARTH

Background information for this section is contained in Appendix I, Hydrogeologic Evaluation prepared by Associated Earth Sciences Inc.

3.1.1 Affected Environment

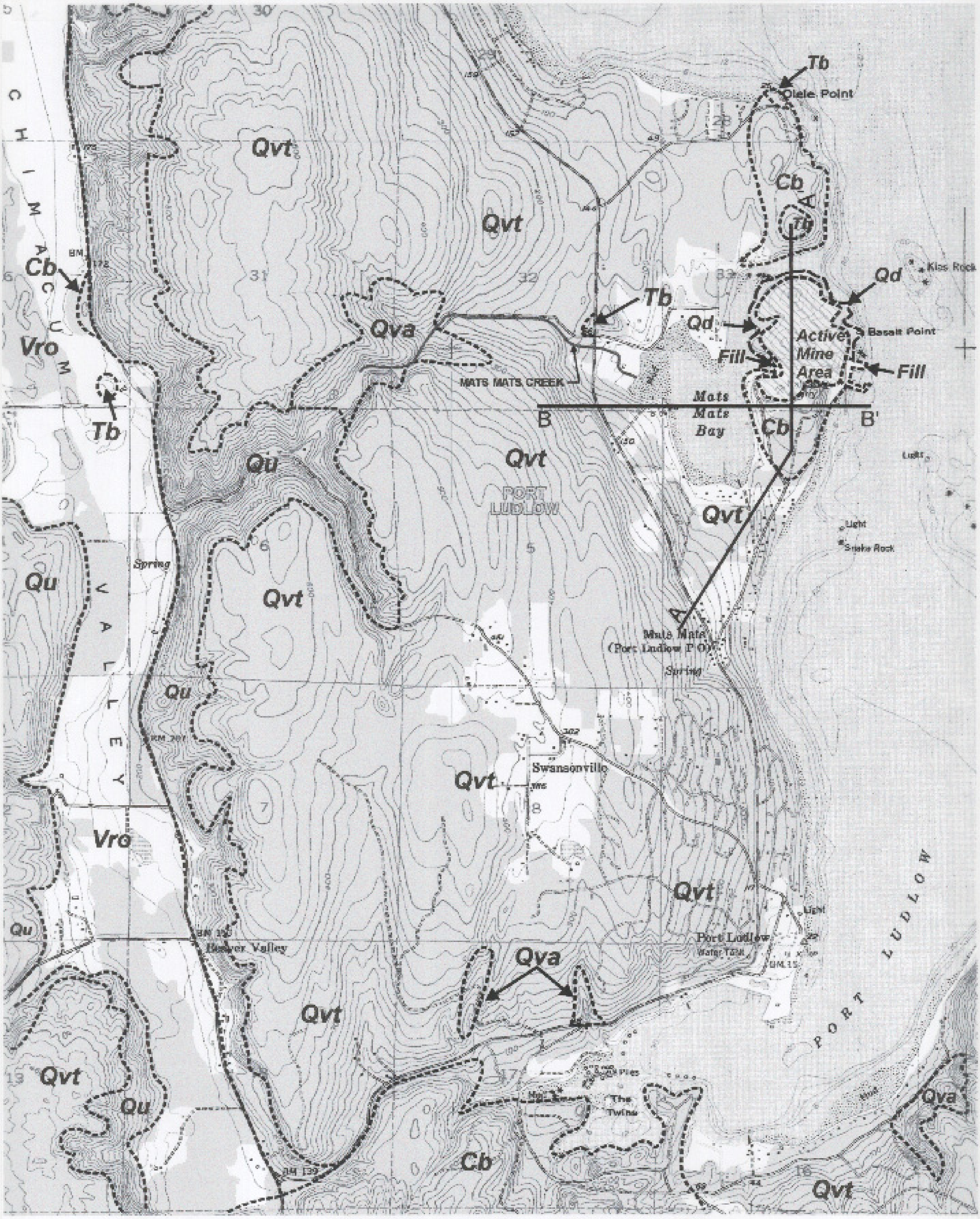
Regional Geology

Regional geology in the vicinity of the Mats Mats Bay area consists of basaltic bedrock overlain by variable thicknesses of unconsolidated glacial and nonglacial deposits. The geologic units at and in the vicinity of the Mats Mats Quarry are described below from oldest in age to youngest. A regional geologic map of the Mats Mats Bay area is presented as Figure 3.1-1, and geologic cross sections are presented as Figures 3.1-2 and 3.1-3.

Basalt Bedrock

Basalt bedrock on the site and in the site vicinity is mapped as the Crescent Formation (Tb). The Crescent Formation is an Eocene age (about 50 million years old) series of basaltic lava flows and sedimentary deposits that wrap around the lower portion of the eastern Olympic Mountains. The Crescent Formation basalt was formed in relatively shallow marine waters, prior to the uplift of the Olympic Mountains approximately 35 million years ago.

The individual lava flows of the Crescent Formation are separated by sedimentary “breaks” or sequences, which form a boundary between individual lava flows. After a period of several million years, the lava flows and sediments were tilted with the uplift of the Olympic Mountains (refer to *Site Geology* for additional discussion on basalt formation).



Adapted from Grimstad and Carson (1981) and Hanson (1977)

LEGEND

Vro	Undifferentiated Holocene and Vashon Recessional deposits
Qd	Vashon drift
Qvt	Vashon lodgement till
Qva	Vashon advance outwash
Qu	Undifferentiated glacial/non-glacial deposits
Cb	Basalt overlain by thin till
Tb	Basalt
A —— A'	Cross section location

N

0 2000

SCALE IN FEET

REFERENCE: DELORME MAPS.

Source: Associated Earth Sciences, Inc.

Huckell/Weinman Associates, Inc.

HWA

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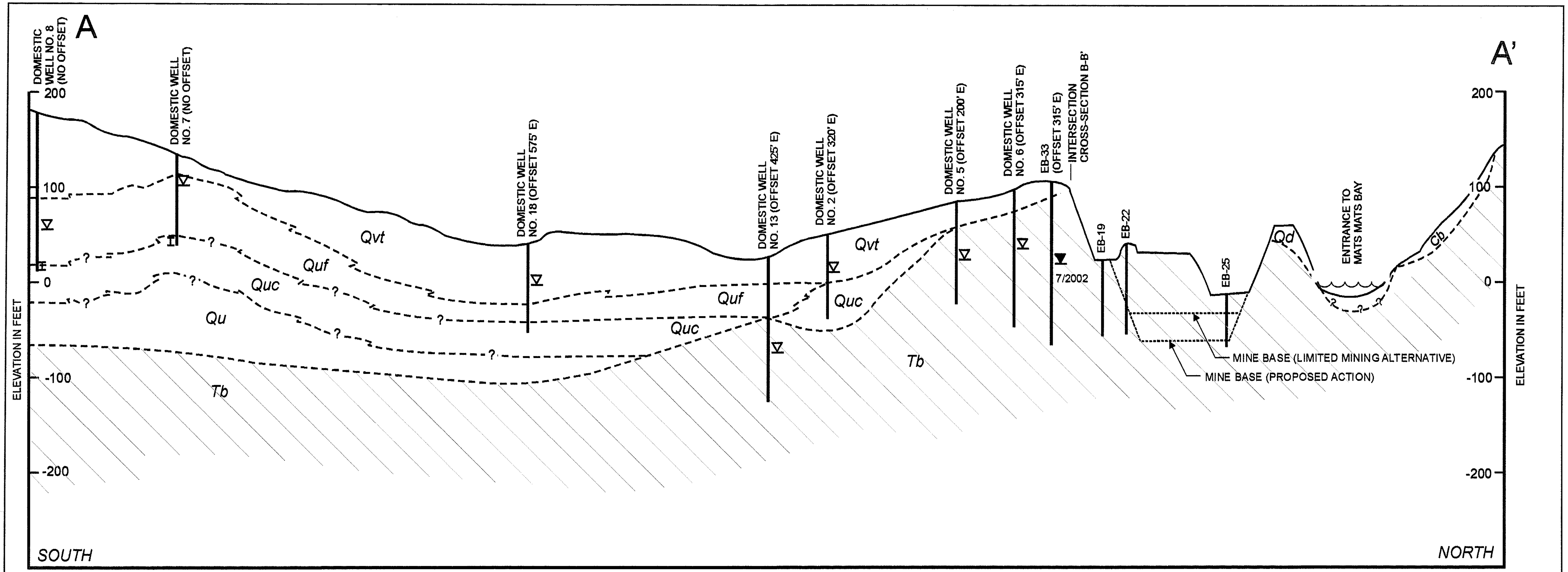
Figure 3.1-1

Regional Geology



LEGEND

Qd	Vashon drift (undifferentiated)
Qvt	Vashon lodgement till
Quf	Undifferentiated glacial/non-glacial deposits (fine-grained)
Quc	Undifferentiated glacial/non-glacial deposits (coarse-grained)
Qu	Undifferentiated glacial/non-glacial deposits
Tb	Basalt - Crescent Formation
▽	Static water level (at time of drilling)
▼	Static water level July 2002
I	Well screen
....	Proposed mine expansion

NOTE: THE Cb UNIT (BASALT OVERLAIN BY THIN TILL) DEPICTED IN REGIONAL GEOLOGIC MAPS BY GRIMSTAD AND CARLSON (1981) AND HANSON (1977) (SEE FIGURE 8) IS DESIGNATED AS Qvt FOR THE PURPOSE OF CORRELATING THE TILL/"HARDPAN" UNIT DESCRIBED ON DOMESTIC WELL LOGS WHERE AVAILABLE.

HORIZONTAL SCALE IN FEET
0 500
0 100
VERTICAL SCALE IN FEET
VERTICAL EXAGGERATION 5X

Source: Associated Earth Sciences, Inc.

Huckell/Weinman Associates, Inc. HWA

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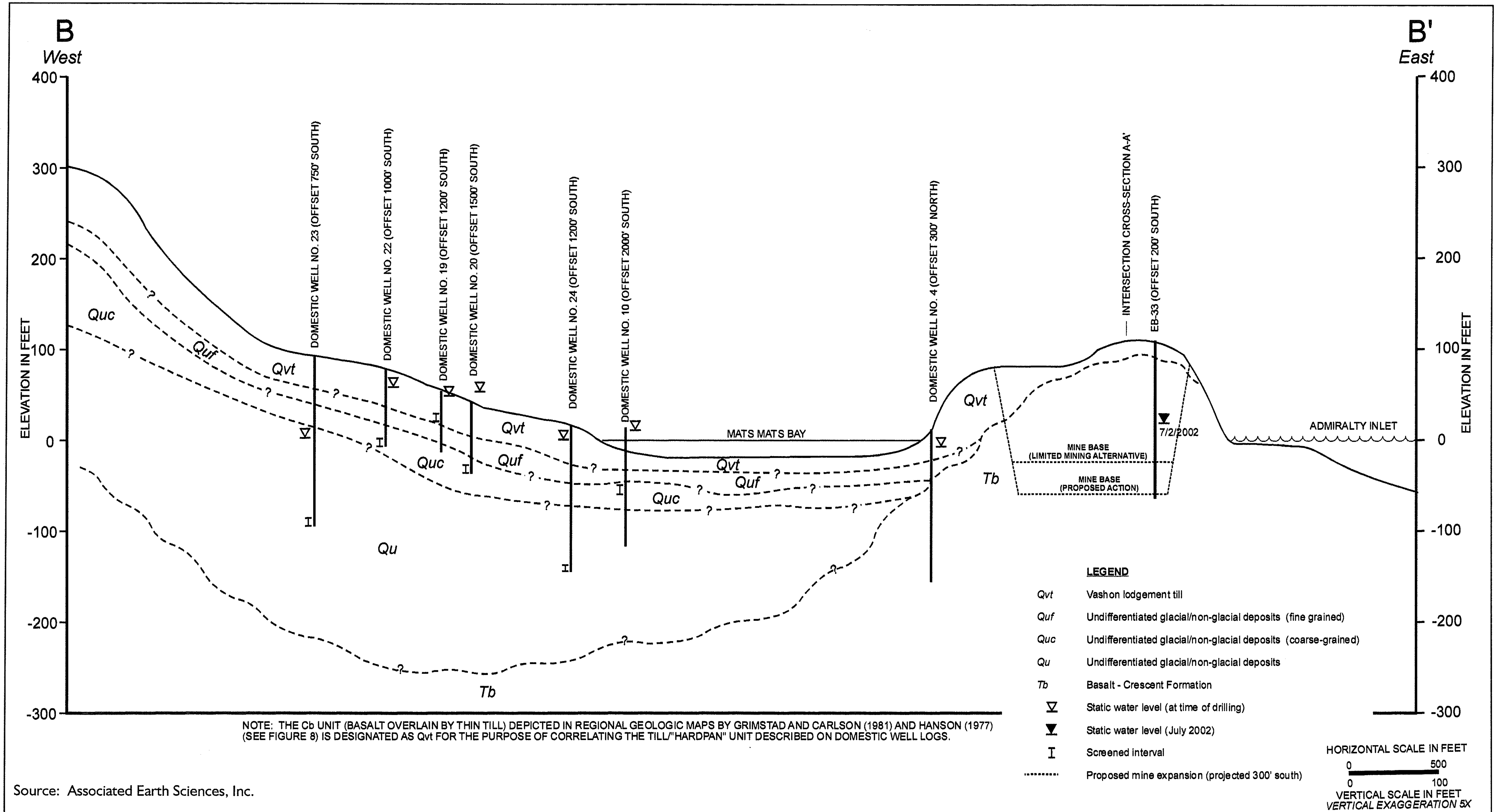
Figure 3.1-2

Geologic Cross Section A-A'



NOTE: THE Cb UNIT (BASALT OVERLAIN BY THIN TILL) DEPICTED IN REGIONAL GEOLOGIC MAPS BY GRIMSTAD AND CARLSON (1981) AND HANSON (1977) (SEE FIGURE 8) IS DESIGNATED AS Qvt FOR THE PURPOSE OF CORRELATING THE TILL/"HARDPAN" UNIT DESCRIBED ON DOMESTIC WELL LOGS.

Source: Associated Earth Sciences, Inc.

Huckell/Weinman Associates, Inc. HWA

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Figure 3.1-3

Geologic Cross-Section B-B'

Unconsolidated Deposits

Subsequent to the formation of the basalt bedrock, sediments were deposited throughout the Puget Lowland during several glacial and nonglacial intervals over the last 2.4 million years. Sediments from the most recent glacial episode, the Fraser Glaciation, are widely exposed at the surface in the Puget Lowland. Exposures of older glacial and nonglacial deposits are typically limited to bluffs and river valley walls. The Fraser Glaciation consists of multiple stades (episodes of glacial deposition). These sediments are present over a majority of the ground surface in the Mats Mats area (refer to Appendix I for detail on area geology).

The presence of mapped outcrops of the Crescent Formation basalt in the Chimacum Valley indicates that basalt is located beneath the glacial deposits. The unconsolidated glacial/nonglacial deposits are relatively thin north of the quarry where the Crescent Formation basalt is present at or near ground surface. North and northwest of Mats Mats Bay the thickness of the unconsolidated deposits is variable, ranging from approximately 20 to 80 feet. The major units of unconsolidated deposits in the Mats Mats area include Undifferentated Pre-Fraser Deposits (Qpfu), Vashon Advance Outwash (Qva), Vashon Lodgement Till (Qvt) and Vashon Drift Over Basalt (Cd) (refer to *Appendix I* for additional detail).

Site Geology

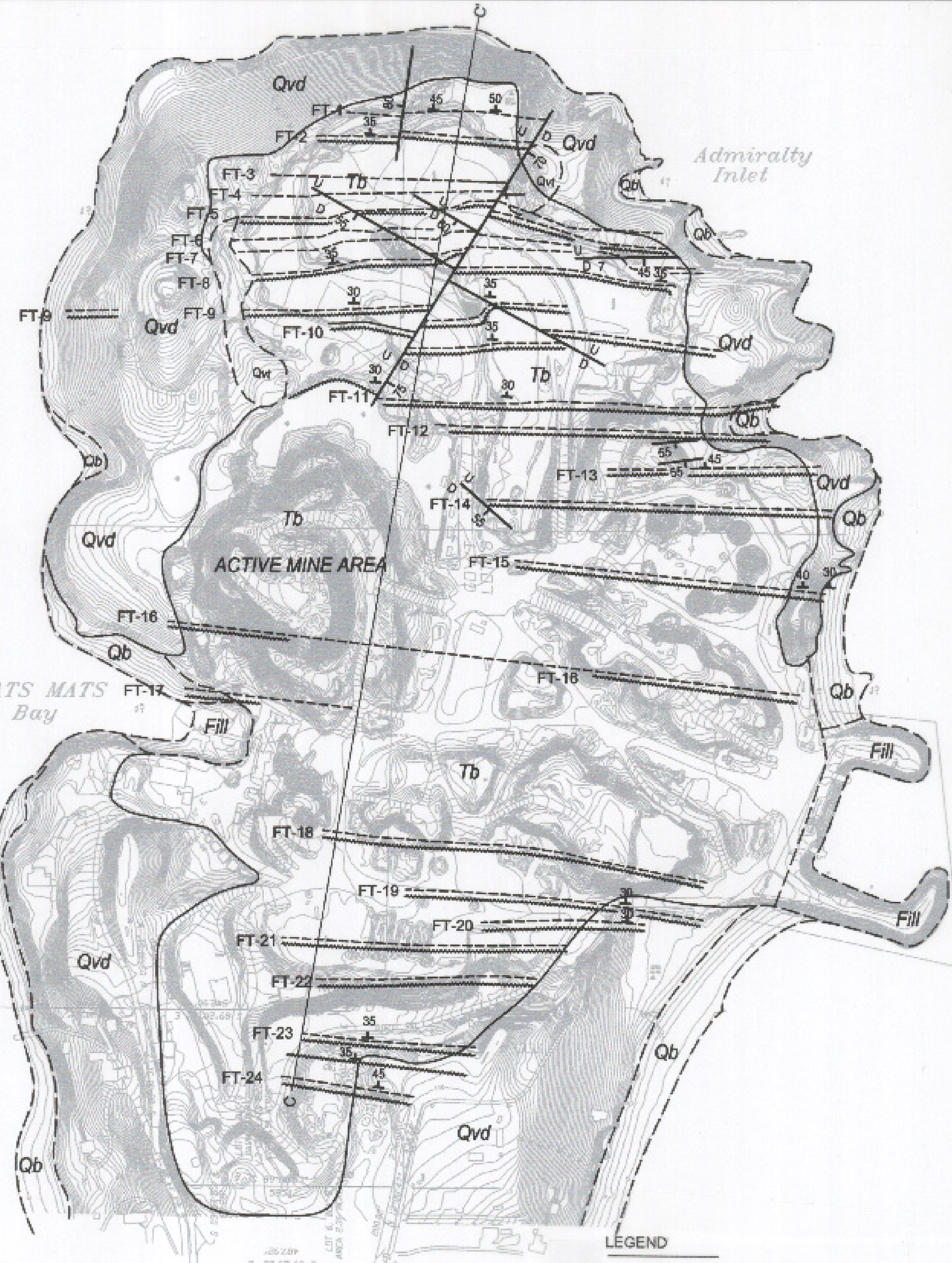
As for the region, geologic units at the Mats Mats Quarry include basalt (Cresent Formation), and unconsolidated deposits consisting of Vashon lodgement till, and Vashon Drift (see Figure 3.1-4). Beach sand and fill are also present. A geologic cross section summarizing surface and subsurface geology at the site is presented in Figure 3.1-5.

For the basalt bedrock, four distinct layers are present:

1) At the base of a flow is an approximately one foot thick zone consisting of aphanitic (microcrystalline) basalt. This zone commonly has good rock quality and is rather impermeable.

2) Above the aphanitic zone is massive columnar jointed basalt that can be up to several tens of feet thick. This zone cooled more slowly but is still fine grained and is characterized by interlocking polygonal cooling fractures that run perpendicular to the cooling surface creating a series of parallel columns. This zone is also characterized by relatively good rock quality and is relatively impermeable.

3) Overlying the columnar jointed section is a layer of pillow lavas and pillow breccias (broken pillows) that are bulbous shaped to cobble-like. This zone can be up to about 15 feet thick at the site and represents the top of an individual lava flow which has reacted significantly with sea water. The pillow shape is caused by sea water cooling. This zone has reacted the most with sea water and therefore contains an abundance of secondary minerals. Solidified gas cavities, or vesicles, are also abundant in this upper zone and the cavities have generally been filled with whitish minerals such as calcite, aragonite, and quartz. The abundance of soft secondary minerals gives this zone poor rock quality. The brecciated character could also facilitate groundwater seepage.



LEGEND

Interflow sediments and tuff (Individual lava flow numbered from north to south)

Pillowed basalt and pillow breccia (flow tops)

35 Strike and dip of flow and interflow sediment

U D 55 Fault with relative displacement and dip

Qb Beach sand

Qvd Vashon glacial drift

Qvt Vashon lodgement till

Tb Basalt - Crescent Formation (where bedrock is exposed) Some areas include stockpiles of fill soils and processed mine aggregate stockpiles

REFERENCE: BASE MAP BY NIES MAPPING GROUP, INC. FOR "MATS MATS QUARRY", DATED 6/30/95.

Source: Associated Earth Sciences, Inc.

Huckell/Weinman Associates, Inc.
HWA

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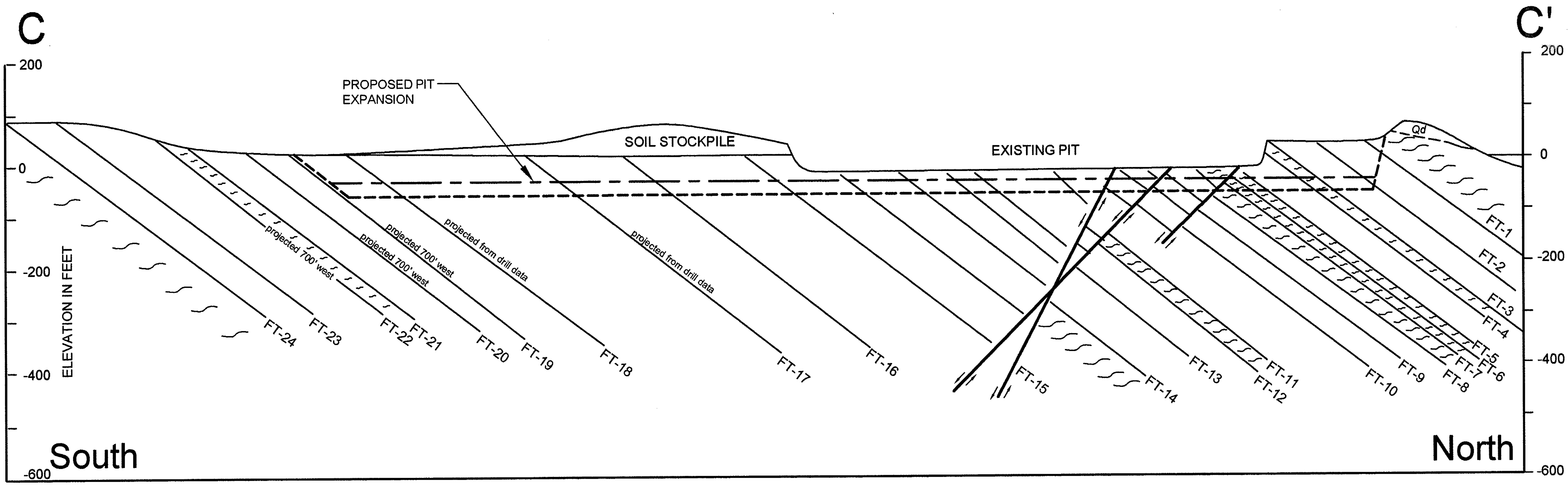
Figure 3.1-4

Site Geology



LEGEND

- Limited Mining Alternative mine base (-30 MLLW)
- Proposed Action mine base (-60 MLLW)
- Basalt flow top
- Columnar jointed basalt
- Fault with relative displacement
- *Qd* Vashon drift (undifferentiated)

HORIZONTAL SCALE IN FEET
0 200 400
0 200 400
VERTICAL SCALE IN FEET

Source: Associated Earth Sciences, Inc.

Huckell/Weinman Associates, Inc.
HWA

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Figure 3.1-5

Geologic Cross Section C-C'

4) As the basalt flow cooled, small fragments of rock debris and volcanic glass (now altered to soft chlorite) settled atop the pillowed zone. The sedimentation continued uninterrupted until the next lava flow covered this sedimentary "break" (layer of sediment deposited between lava flows). The thickness of a sedimentary break is a measure of the length of time between lava flows. Thick sedimentary breaks indicate a long time between lava flows. Thin to nonexistent breaks indicate that the flow of lava continued relatively uninterrupted from one flow to the next. When a sedimentary break became covered with next lava flow, the heat of the overlying flow baked the underlying sediments creating shale. The shale "breaks" are typically friable, with poor rock quality and the potential for allowing groundwater seepage.

After a period of several million years, the lava flows and sediments were tilted to their present 35-degree northward dip with the uplift of the Olympic Mountains. During the uplift the basalt flows were offset by a number of relatively small-scale faults that cut across the basalt flows at relatively high angles.

Unconsolidated sediments that historically covered portions of the basalt within the "active" mine area have been removed during past mining operations.

Fill soils at the site consist of native soils that have been removed from the active mine area and imported soils (prior to placement on the site for reclamation, all imported soils were tested to confirm that the soils were clean – see Appendix VI for the Clean Soil Acceptance Policy). Fill soils consisting of stripped native soil at the mine were encountered in several borings completed in the buffer zone. Fill soils were likely placed in the buffer zone during past mining operations at the site, as no mining or reclamation activities are currently occurring in the buffer zone. Fill soils are also present in the vicinity of the abandoned Mats Mats Bay slip, the Admiralty Inlet barge loading dock, and in multiple stockpiles throughout the active mine area. Stockpiles consisting of imported fill soils are present at several locations within the active mine area.

Groundwater movement in the vicinity of the quarry is restricted for the most part to the flow tops and interflow sediments of the basalt. The direction of groundwater flow is therefore strongly controlled by the east-west fabric of the individual basalt flows. Some groundwater movement could also occur along the high angle faults, but these zones are relatively narrow. Very little groundwater moves in a north-south direction across the site, as the groundwater would have to flow through several relatively thick layers of nearly impermeable columnar basalt. Based on the site geology, flows and sediments, taken as a collective unit, have very low permeabilities and are considered an aquiclude (barrier to groundwater flow). Please refer to the *Water* Section for additional detail on groundwater.

Geologic Hazards

Existing geologic hazards identified within the project vicinity include potential landslides and erosion hazards. Landslide and erosion hazards were assessed through visual geologic reconnaissance, subsurface explorations, and review of existing geologic literature. The existing geologic hazards on-site and in the immediate vicinity of the site are discussed below.

Landslide Hazards

A site reconnaissance revealed no evidence of landslide activity was noted within the quarry. With the exception of areas actively being mined, the bedrock typically has a low risk of slope instability.

An off-site reconnaissance of private properties on the west side of the inlet to Mats Mats Bay was completed during September 1999 to evaluate reported landslide activity. Several landslides were identified on the west side of the inlet leading to Mats Mats Bay. This slope is composed of Vashon Drift sediments and is approximately 30 feet high. Where observed, slope gradients were estimated at 80 to 100 percent. Three slides were noted in this vicinity during the site reconnaissance. All three slides showed evidence of recent activity. In several areas, bank retreat from 10 to 20 feet was observed. Erosion from wave action was also noted at the toe of the slopes. Based on conversations with one of the property owners, landslide movement along this slope occurred sometime between 1996 and 1999.

The Washington State Department of Ecology's Coastal Zone Atlas (DOE, 1978) identifies relative slope stability categories on coastal lands of the state. According to the Atlas, the majority of the site is designated as "Stable Slopes" (including areas of low groundwater concentration or competent bedrock). The shoreline slope areas outside of the mining area are designated as "Intermediate Slopes" (slopes over 15 percent with thin soils over bedrock). The barge loading area is designated as "Modified Slopes" (areas highly modified by human activity).

Erosion Hazards

No recent evidence of erosion was observed in the Mats Mats Quarry at the time of fieldwork. The bedrock is relatively competent and resistant to erosion from concentrated and sheet flow. Fine-grained sediment was observed to have accumulated within the Mats Mats Bay slip. Silt fencing had been placed around the perimeter of this area. The silt fencing was observed to be in disrepair at several locations. It is understood that the silt fence was installed by the previous property owner when the back portion of the Mats Mats Bay slip, in the southwest portion of the property, was used as a sediment trap. Glacier Northwest discontinued the use of the back portion of the slip as a sediment trap in 1995 and the silt fence is no longer required to trap sediments. Glacier Northwest has not proposed to remove or repair the silt fence.

3.1.2 Impacts of the Proposed Action

The primary impact of the *Proposed Action* is the depletion of a portion of the remaining bedrock reserves at the site. Approximately 9 million tons of rock would be mined from the site over a projected mine life of approximately 18 years. Issues associated with resource extraction principally concern modification of existing topography and related wall stability concerns (refer to the *Groundwater* section for detail on the potential for saltwater seepage).

Modification of Site Topography

The existing surface topography of the site would be modified as rock resources are extracted. Approximately 61 acres of the 117-acre site have been mined in the past. The proposed mining would occur in areas currently modified by mining activities and significant modification of the surface extent of mining would not occur. The existing quarry floor, with a lowest elevation of approximately 13 feet below MLLW would be deepened to approximately 60 feet below MLLW. The proposed topographic modifications would be contained within the current quarry footprint and visual impacts from topographic modifications would be limited (refer to the *Land Use* section).

The proposed reclamation plan includes continuous filling to establish the topography necessary for final reclamation. It is anticipated that approximately 7.3 million cubic yards of material would be required to establish a final floor elevation ranging from approximately 20 feet to 30 feet above the mean lower-low sea water elevation (MLLW).

Slope Stability and Landslides

In quarry mining operations, bedrock instability is generally limited to translational block failure of the rock high wall, as opposed to conventional sliding commonly observed in the younger, non-rock sediments in the region.

The central, southern and western portions of the Mats Mats Quarry contain intersecting faults that may produce rock fall where two planes of weakness (faults) intersect. This potential for rock fall is typical of rock quarries and would not impact off-site areas. No intersecting faults have been mapped within the eastern and northern portions of the quarry, although it is possible that some faults extend into these areas. In addition to the faults, bedding planes (sediment layers) between the successive basalt flows are present. It is anticipated that rock movements along the bedding planes would not be a significant threat to highwall stability because the bedding dips downward and away from the pit excavation. Although rock movement within the quarry would not represent a threat to highwall stability, awareness of localized rock movement for the safety of mine workers would be required.

To further determine the anticipated integrity of the highwall between the salt water and the quarry interior, a *Highwall Stability Analysis* was prepared (Refer to Appendix X). Highwall stability was evaluated with a mathematical simulation (a model) to determine whether the wall will remain stable or fail under a variety of conditions. The stability analysis is used to determine the strength of the wall under static (no earthquake shaking) and seismic (with earthquake shaking) conditions. The stability of the slope for each condition is expressed as a value called the factor of safety. A calculated factor of safety of less than 1.0 predicts that the wall will fail. A factor of safety of 1.0 predicts that the wall is at the margin of stability, and a factor of safety greater than 1.0 predicts that the wall is stable. However, the greater the number above 1.0, the more stable the wall. For the proposed quarry depth, a calculated factor of safety of 1.5 and above is considered safe for non-seismic conditions and a 1.15 factor of safety is considered safe for seismic conditions.

The analysis concluded that the highwall between the salt water and the quarry interior (east and north highwall) would have a factor of safety in the range of 1.6. The calculated factor of safety of 1.6 exceeds the standards for both non-seismic and seismic conditions with no significant risk of highwall failure anticipated. The factor of safety for the west and south highwalls would be higher than that of the east and north highwalls due to the lack of hydrostatic pressure from Admiralty Inlet.

Movement of rock would occur during blasting. Any debris from block failures in the interior portion of the highwall during mining would be contained on-site and collected for processing.

There is no evidence that block failures would extend beyond the proposed mining limits. However, measures are identified to address this low risk as outlined under *Mitigation* .

Under the proposed reclamation, the bedrock slopes would be backfilled to gradients no steeper than 3H:1V utilizing imported fill material. Loose and/or saturated fill material on sloping ground may be susceptible to movement, particularly during seismic events. In addition, uncontrolled surface water runoff over the top of the fill slopes could promote erosion, oversteepening, and subsequent slope stability hazards. Measures are identified to address erosion as outlined in the *Mitigation* portion of this section.

Off-site landslides were observed on the west side of the passageway to Mats Mats Bay. The observed landslides appear to be the result of oversteepening of the bluff face by past wave action during high tides. Surface water runoff from off-site upslope areas onto the oversteepened slopes likely contributed to the landslide activity, and landslide activity in this area will continue to occur unless the impacts from wave action and off-site surface water runoff are mitigated. Based on past monitoring in the landslide area, vibrations from blasting at Mats Mats Quarry are slight and were unlikely to accelerate the existing, off-site landslide hazards.

Erosion

Sheet erosion is caused by “sheets” of water flowing over the cleared land surface and transporting soil particles. The surface flow rarely moves as a uniform sheet for more than a few feet before concentrating in surface irregularities resulting in “rill erosion”. Additional sediment is eroded in the concentrated rills. The “rill erosion” process is continuous over several storms or normal rainfall events. If the rills erode to more than a few inches deep, then the erosion regime changes to “gully (channel) erosion” where concentrated water flow can transport large quantities of sediment during a single storm event.

The bedrock on the site is generally sound and competent and would typically be resistant to both sheet and channel erosion, and is considered to possess a low risk of erosion. Any potential sediment transport generated during mining or rock crushing would be directed into the on-site sediment ponds located on the western side of the quarry.

Imported soils would be placed during the reclamation phase and would ultimately cover the bedrock faces created during mining. Slope gradient and vegetation would control the amount of erosion on the fill soil surface. In general, steep slopes on non-bedrock material can have a high susceptibility to erosion as surface water on steep slopes has the capability of achieving higher velocities than on shallow slopes and, hence, more energy is available to erode and transport sediments. Vegetation would reduce the potential development of concentrated flows by dispersing rainfall, impeding surface water flow, and reducing surface water velocities. The proposed fill soils are considered to have moderate erosion hazard risk since the proposed reclaimed slope gradients would be relatively gentle (3H:1V or less). With proper implementation of mitigation measures proposed for during and after fill placement, significant erosion impacts would not be anticipated.

3.1.3 Impacts of the Alternatives

No Action

Under the *No Action Alternative*, mining conditions under the existing surface mining and reclamation permits would continue – mining would occur to a depth of approximately 0 feet below MLLW compared to 60 feet below MLLW under the *Proposed Action*. The level of site modification would be less than under the *Proposed Action*. Although not identified as a significant impact under the *Proposed Action*, the potential for marine water intrusion and highwall stability impacts would be less than under the *Proposed Action*. Mining and reclamation operations and resultant earth impacts would end approximately 18 years earlier than under the *Proposed Action*.

Limited Mining

Under the *Limited Mining Alternative*, mining would occur to a depth of approximately 30 feet below MLLW compared to 60 feet below MLLW under the *Proposed Action*. The level of site modification would be less than under the *Proposed Action*, although the mining footprint would be the same. As under the *Proposed Action*, mining under this alternative would increase the potential for marine water intrusion and highwall stability impacts; as under the *Proposed Action*, the potential for highwall stability impacts would not be significant. Mining and reclamation operations and resultant earth impacts would end approximately 10 years earlier than under the *Proposed Action*.

3.1.4 Mitigation Measures

Planned mitigation for the *Proposed Action* and Alternatives largely consists of site reclamation efforts to restore and stabilize areas disturbed during mining. Specific reclamation issues would be addressed as a revision to the Proponent's current Surface Mining Permit. As a key component, the overall reclamation strategy is intended to address requirements of the Surface Mining Act, Chapter 78.44 RCW, as amended in 1993.

Landslides

The following measures are included as part of the proposal.

- No surface water features would be constructed above the bedrock slopes around the perimeter of the mine limits during mining or reclamation activities to avoid recharging potential planes of weakness in the rock slopes.

- During reclamation, the final bedrock slopes would be buttressed with imported fill material, and the risk of block failure in the bedrock would remain low. Additional mitigation measures could be implemented if necessary prior to placing the imported fill soils to reduce the risk of failure of the final bedrock slopes such as those outlined at the end of this section. The type of mitigation measure(s) required would depend on the site-specific conditions and would be determined at the time of mining.

- Reclaimed fill slopes would be placed at gradients no steeper than 3H:1V.

- The fill would be compacted following the earth embankment standards outlined in Washington State Department of Transportation's (WSDOT's) Standard Specifications (2000).

In addition to the mitigation measures included in the proposal, the following measures are recommended to further reduce the potential for landslide impacts.

- During reclamation, modifications to slope gradient and compaction effort may be necessary during fill placement to adjust for variations in grain size and moisture content of the fill material.

- Adequate drainage should be provided to facilitate the placement and compaction of fill soils. Water needing to be pumped from low areas of the mine would be directed to the stormwater conveyance and treatment systems. Storage ponds would not be constructed above the fill slopes to reduce the risk of recharging the fill soils and promoting slope instability.

Erosion

The following measures are included as part of the proposal.

- During mining, stormwater would be directed into a multi-cell pond system similar to the one currently being used at the site. All of the stormwater would be treated and discharged to Mats Mats Bay in accordance with the existing National Pollutant Discharge Elimination System (NPDES)/Stormwater Discharge Permit issued for the site. Sediment from the quarry area would be intercepted by these ponds, and the risk of off-site sediment transport hazards is considered low.

- The reclamation fill soils would be placed at relatively low gradients, and the risk of erosion is considered low. Stormwater runoff from the reclaimed pit would be directed into the proposed sediment pond to be constructed on the east side of the quarry area. This pond would release water into Admiralty Inlet via an energy dissipater. Localized surface water runoff near the northern edge of the site would be directed into small infiltration areas. Runoff from these areas would remain on-site, and no risk of off-site sediment transport has been identified.

In addition to the mitigation measures included in the proposal, the following measures are recommended to further reduce the potential for erosion impacts.

- Stormwater runoff from the bedrock mine area should not be directed to sloping areas or allowed to randomly discharge on the site. Stormwater or intercepted groundwater seepages within the bedrock should discharge into riprapped drainage ditches that empty into the approved sedimentation ponds. Runoff from saturated fill soils should also be directed into properly constructed conveyance systems.

- To reduce the risk of surface water runoff on the fill slopes triggering erosion and sediment transport, it is recommended that the fill slopes be constructed with a bench every 25 vertical feet. The bench would reduce surface water runoff velocities and the risk of rill and channel erosion. The benches should be backsloped into the hillside. Runoff from the benches should be directed to the proposed sediment pond or the proposed stormwater depressions. Any runoff paths on slopes greater than 5H:1V should be lined with riprap and check dams constructed every 75 lineal feet.

- Source control mitigation measures for reclaimed fill slopes should include the proper placement of hydroseeding and straw mulch (tacked down). In addition, prior to revegetation of the fill soil, the slopes should be trackwalked (up and down) in order to roughen the ground surface and reduce runoff velocities.

3.1.5 Significant Unavoidable Adverse Impacts

None are anticipated.